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Coordinated development between metropolitan economy and logistics for sustainability

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ABSTRACT

Logistics sustainability plays a critical role in our daily life since logistics involves in large number of resources such as manpower, transportation vehicles, warehouses, and products which should be sustainably leveraged. One possible way to achieve the sustainability is to make the coordinated development of logistics and economy. Due to the complexity of the logistics industry, better coordination among all relevant parties are challenging. The purpose of this research is to analyze the key factors on the coordinated development between metropolitan economy and logistics. This paper uses a Bayesian Network to examine their impacts. Several contributions are significant. Firstly, it is observed that the coordinated development of metropolitan economy and logistics heavily relies on their development levels as their posterior probability values are both over 80%. Secondly, two causation chains greatly affected the coordinated development are found. Scientific value of this research is that special attentions should be paid to key factors like logistics infrastructure investment, the development level of logistics industry, basic research and development level, and the technological development level within the chains when carrying out sustainable decision-makings.

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1. Introduction

Metropolitan economic is the cohesive, naturally evolving concentration of industries, commerce, markets, and other economic elements in a particular metropolitan area (Solís Trapero et al., 2015). It determines the demand structure and development level of logistics (Fullerton et al., 2015). Metropolitan logistics refers to the management of flow of things between the point of origin and destination to meet customer requirements within a metropolitan area (Woudsma et al., 2016; Lan et al., 2016). Coordinated development refers to cooperate more than two parties or resources so as to achieve an objective under win-win situation. For example, in 2015, Sinopec demonstrated that coordination is the inherent requirement of sustainable development (Sinopec, 2015). The coordinated development of economy and logistics plays an important role in supporting the sustainability of our society. On one hand, logistics involves large number of resources such as manpower, transportation vehicles, warehouses, and products which should be sustainably leveraged. On the other hand, the fast economy step pushes the logistics so as to meet the requirements from our

society. The coordinated development between metropolitan economy and logistics may result in a sustainability of better usage of resources (Münter and Volgmann, 2014).

Sustainable logistics refers to a balanced minimization of the ecological impact of logistics activities such as the forward and reverse flows of products, information and services between the point of origin and the point of consumption, etc (Grant et al., 2015; Taskhiri et al., 2016). One of the key steps, from a DHL report – Delivering Tomorrow: Towards Sustainable Logistics, is the measurement of coordinated development between metropolitan economy and logistics. Since key impact factors like strategies, network design, and transportation will largely influence the ecological consciousness, economics perspectives will be affected ultimately (Lee et al., 2010). Thus, it is significant to study the coordination between economy and logistics. Specifically, analysis of key impact factors on coordinated development between metropolitan economy and logistics is important to achieve sustainable logistics.

Despite many efforts have been placed on coordinated development of economy and logistics (Chandra et al., 2016; Jensen and Hertz, 2016), further investigations are still needed. Firstly, key factors that affect the coordinated development are not clearly identified. Some key factors such as equipment update rate and technology level are not considered for determining the coordi-

nated relations and their evaluations. Secondly, the relations of each key factors are not systematically labelled so that casual chains of the economy and logistics coordination are omitted. Thirdly, how logistic systems will effectively improve regional logistics is limitedly studied in terms of quantitative and qualitative analysis. Finally, practical issues are not always considered in literature so that managerial implications are difficult to obtain.

In this paper, the inner mechanism of the coordinated development between metropolitan economy and logistics is presented by examining its key factors and their relations. The aims of this paper are to work out the key factors greatly influence the coordinated development and to propose some implications for decision makers. In the first place, the basic constructing elements related to logistics and economy as well as qualitative indicators in line with different layer classifications are demonstrated to establish a four-layer quantitative index system. Secondly, with the application of Bayesian Network model, the interrelationship among these factors is determined, especially the degree which will influence on each other. Thirdly, the probability of each factor is conducted through Bayesian formula. Using the posterior probability, it is able to find out the most significant factors that impact the coordinated development to establish a causal chain (Wang et al., 2016).

By analyzing the causal chain and related routes, this paper provides references in promoting the coordinated development between logistics and regional economy so as to achieve sustainable logistics. Using a Bayesian Network simulation tool – GeNle, evaluations are carried out on the key factors which will affect the coordinated development e. The rest of this paper is organized as follows. Section 2 gives a brief literature review of related work such as Bayesian Network and coordinated development of economy and logistics. Section 3 presents the method. Results and discussions are demonstrated in Section 4. Section 5 gives the implications. Section 6 concludes this paper by giving our key findings and future research directions.

2. Literature review

This section briefly reviews related works including Bayesian Network and coordinated development between economy and logistics. A summary of the research gaps is presented after the literature review.

2.1. Bayesian Network

Bayesian Network is a reasoning network based on probabilistic uncertainty (Pearl, 1985). It is a probabilistic graphical model which represents a set of random variables and their conditional dependencies through a directed acyclic graph (Dikgang et al., 2012). Bayesian Network based on the theories of probability and statistics plays an important role in studies on uncertainties (Dabić-Ostojić et al., 2014). A Bayesian Network is able to represent the probabilistic relationships between diseases and symptoms so that diagnoses could be carried out (Seixas et al., 2014). In a switchgrass-based bioenergy system, Bayesian Network is used to evaluate life cycle CO_2 emission with an agent-based life cycle assessment (Bichraoui-Draper et al., 2015). A dynamic Bayesian Network was proposed by using a structural interface algorithm for exacting probabilistic inference (Vlasselaer et al., 2016). The approach not only exploits the repeated structure in the network, but also the local structure including determinism and parameter equality.

Bayesian Network has been widely used in applications due to its advantages. In order to deal with the contexts of environmental modeling and management, (Uusitalo, 2007) proposed a use of Bayesian Network in terms of software products and applications. This paper analyzes the ecosystems and environmental manage-

ment to get rid of the uncertainties and complexities. Bayesian Network was also used to determine the probabilistic influential associations among software metrics and defect proneness (Okutan and Yıldız, 2014). An analytical framework for supply network risk propagation using Bayesian Network was presented (Garvey et al., 2015). Through simulation study, the framework is able to perform the measurements in a supply network setting. An intelligent Bayesian Network model was introduced for medical decision supporting from complex questionnaire and interviewing data (Constantinou et al., 2016). It is observed that both applications provide improvements in predictive accuracy and decision support.

2.2. Coordinated development between economy and logistics

Coordinated development between economy and logistics plays an important role in stimulating the economy growth of a metropolitan domain. This section categorizes related works into theoretical and practical perspectives. For theoretical perspective, models, frameworks, and mechanisms are briefly reviewed. Using the most updated data from Chinese logistics and economy, Lean et al. (2014) used a dynamic structural model to test the relationship between the both items. The tested results show that the economic development brings about more demand for logistics services. A theory-based framework considering coordinated logistics was introduced to achieve mutual trust among partners and the extent of the coordination (Pomponi et al., 2015). This framework uses a "synthesising" approach to gauge potential contributions previously spread across different streams of disciplines integrated into it. In order to examine the performance in the coordinated development, (Estampe et al., 2013) proposed a framework for the purpose. An analytical grid breaking approach is used for breaking down the models into 7 layers. A hybrid artificial bee colony algorithm with hybrid operators with comprehensive analysis was introduced to the logistics and economy coordination development (Zhang et al., 2014a). Through this algorithm, practical insights are provided for operation management in sustainable logistics.

Currently, as the rapid growing of logistics and supply chain management driven by the cutting-edge techniques, the coordinated development between basic perspective (logistics) and soft part (economy) has attracted great myriad of attention from practitioners (Qiu et al., 2015). Economy and logistics are mutually and complementarily promoting since most of the living necessities are needed to be delivered. On one hand, economy development determines the degree of development of logistics and then stimulates its future growing (Agrawal et al., 2015). On the other hand, the logistics development will shift the economy with a region. Thus, (Hong-wen et al., 2007) verified the interaction between the two perspectives using statistical analysis. They concluded that the economy of China plays a more important role in boosting the logistics industry which should be further accelerated in the near future. Owing to the development of logistics services, take the independent logistics industry for example, most of the research places the emphasis on political aspects. Whereas, the coordinated development is seldom studied. (Coe, 2014) distilled the major contributions and limitations of prevailing business studies methodologies to logistics within the global economy. This paper analyzes the implications of on-going post-crisis restructuring with the world economy for logistics. Regional Logistics-Economic system has attracted much attentions. In order to realize the collaborative barriers in coupling development of the system, a conceptual and constitutional framework was constructed (Wang and Lu, 2015). This paper introduces a reasonable evaluation index system to measure the coupling development degree.

From the literature, several research gaps could be identified. Firstly, the coordinated development between logistics and econ-